

ASSEMBLY FOR PURIFYING WATER

CROSS REFERENCE TO RELATED APPLICATION

5           This application is a continuation-in-part of Applicant's copending patent application number 09/752,982, filed 12/31/2000, and Applicant's copending patent application number 09/393,437, filed 02/27/01, and which will issue on 02/27/2001 as US patent number 6,192,911.

10   FIELD OF THE INVENTION

          This invention relates to ozone-based water purification systems. More particularly, this invention relates to water purification systems utilizing a counterflow system in conjunction with a mixing venturi in order to allow premixing of compounds prior to introducing the mixed compounds in a flow of  
15   water for a spa, hot tub, swimming pool or the like.

BACKGROUND AND SUMMARY OF THE INVENTION

          Commonly known ozone water purification systems comprise the elements of an ozone gas generating apparatus, a water carrying tube including  
20   an ozone contact segment, and in some instances a bubble separating column or chamber. The ozone generating apparatus may comprise a cylindrical chamber through which atmospheric air containing diatomic oxygen is pumped

or drawn. Radiation from a lamp capable of emitting intense ultraviolet light having a wavelength of approximately 185 nanometers and 254 nanometers excites the diatomic oxygen within the chamber. As a result of such molecular excitation, a fraction of the diatomic oxygen within the chamber is split, producing free atoms of oxygen. The extremely high chemical reactivity of free oxygen atoms within the chamber causes them to rapidly react with the remaining intact oxygen, forming ozone gas (O<sub>3</sub>).

Another commonly known method of producing ozone gas within a chamber is to install closely spaced electrodes therein and to apply a sufficiently high electrical potential between the electrodes to produce electric discharge arcing. Diatomic oxygen molecules in close proximity with such electrical arcing similarly degrade into free oxygen atoms, which quickly react with diatomic oxygen to form ozone gas.

In commonly used configurations of ozone water purification systems utilizing ozone, ozone-rich air emitted from the ozone generator apparatus is introduced into a stream of water in need of purification, such water typically moving through a tube. Where air is forced through the ozone-generating apparatus by, for example, an air compressor, the output of the ozone generator may be introduced into the water-carrying tube by a simple air line interlinking ozone-rich air from the ozone generator to an aperture extending through the wall of the water-carrying tube. In other applications, the air line may terminate at a venturi installed in the water line so that water flowing through the venturi provides motive force to draw the ozone-rich air into the

flow of water.

Ozone carrying air either injected into the contaminated water stream or drawn into the stream by a venturi initially exists in the form of air bubbles. In order for the ozone gas to have a purifying effect upon the water, such gas  
5 must be dissolved into the water. Such dissolving of the gas into the water necessarily occurs at the spherical surface tension boundaries between the gas and the water. A high solubility differential between common air components and ozone gas causes the ozone within such air bubbles to dissolve more quickly than other gases. An exception to this occurs where an ozone residual  
10 exists in water in close proximity to the bubbles. Here, rate of infusion of ozone into the water may be reduced due to the strong negative charge of the ozone molecules. In any case, ozone carrying bubbles must remain immersed in water a sufficient length of time to achieve sufficient diffusion of ozone into the water. In addition, it is well known that where the bubbles are kept small,  
15 i.e. prevented from merging into larger bubbles, rate of ozone diffusing into the water is increased. Initially, bubbles from a venturi orifice are small, but soon merge with other bubbles while travelling in the flow of water, which typically just after the venturi becomes laminar.

In some commonly configured ozone water purification systems, the  
20 water-carrying tube serves dual functions, both transporting water containing dissolved ozone to its desired destination, and providing an elongated contact distance where air bubbles containing ozone may remain in contact with the water for a sufficient length of time to allow dispersion of the ozone into the

water. In order for ozone dispersion to occur within the water-carrying tube, the tube must have a sufficient length, i.e., an ozone contact length. The contact length of the tube may typically be between approximately 1 - 4 feet or so, and possibly up to 8 feet in length. However, the length may vary  
5 depending upon variables such as rate of flow within the tube, size of the tube, turbulence and water temperature. Sharp turns within the tube or turbulence-inducing baffles or screens installed within the bore of the water carrying tube may serve the function of breaking larger ozone-carrying bubbles into smaller bubbles, increasing the overall surface area of the bubbles, and increasing the  
10 rate the ozone dissolves into the water. In addition, and as stated, where an ozone residual exists in the water proximate the bubbles, such as where the flow becomes laminar, transfer of ozone from the bubbles is inhibited.

While venturi injectors or mixers such as those used in dissolving ozone into water provide a small bubble size, and as stated, the flow of water  
15 just downstream the injector, within 12 - 15 inches or so, becomes laminar. As such, the bubbles, being entrained in a laminar flow just downstream the injector, become so closely packed together that they merge into larger bubbles. Further, the fluid moving with the bubbles in the laminar flow becomes permeated with ozone, inhibiting further transfer of ozone from the bubbles.

20 Where water having dissolved ozone gas therein is poured into a body of water such as, for example, a swimming pool, the ozone beneficially reacts with various contaminants. For example, ozone rapidly reacts with metal ions within the water, forming precipitants which may be removed through

filtration. Ozone dissolved in water also degenerates or causes lysis of cell walls of bacteria, viruses, protozoan organisms, algae and other microbiota. However, while ozone kills bacteria and viruses almost instantly, protozoa such as those that serve as hosts for bacteria that cause Legionnaires disease  
5 require longer exposure to higher concentrations of ozone in order to be killed. Ozone within water also beneficially oxidizes and neutralizes sulfides, nitrates, chloramines cyanides, detergents, and pesticides. In all such cases, the efficacy of ozone in reacting with such contaminants is enhanced by reducing the physical distance between contaminant organisms or molecules and the  
10 molecules of ozone within the water. In a large volume of water, such as a drinking water storage tank, spa, or swimming pool, the concentration of dissolved ozone becomes undesirably low, slowing the rate at which the ozone reacts with contaminants. To prevent such dilution of ozone concentration, it is desirable to first introduce the ozone-carrying water into a reaction chamber  
15 having a smaller interior volume which maintains higher concentrations of ozone.

In addition to the foregoing, one problem with indoor pools, spas, hot tubs, jetted bathing facilities and other similar immersion facilities that utilize ozone for sanitization purposes is one of outgassing of the ozone into the area  
20 surrounding the facility. Here, strict rules have been enacted that require that outgassing of ozone from such a facility not exceed 0.1 ppm. Thus, it becomes necessary to ensure that little or no ozone is allowed to escape from the water. Further yet, where ozone is generated from air, only a fraction of the

approximately 20% oxygen content of the air is converted to ozone. As a result, a relatively large quantity of atmospheric gasses are introduced into the water flow. In some systems, this is undesirable as the gasses produce cavitation of pumps, and where the flow is fast, can erode pipes and other parts of the water-carrying system. As a result, it is necessary in some systems to remove these atmospheric gasses in order to prevent deleterious effects on the system.

In all systems where ozone is used in conjunction with other sanitizers, such as bromine or chlorine, premixing of the sanitizer with ozone or air containing ozone is beneficial. Here, when ozone is premixed with halogens, such as sodium bromide, the bromine is released. With chloramines that are usually present, free chlorine is released. Where bicarbonate of soda is present, hydroxyl radicals are created, which acts as a sanitizer and increases the oxidation potential of the water. Ozone also increases the ground state of halogen sanitizers so that they are more reactive, increasing their sanitizing effects and potential to reduce contaminants.

In accordance with the foregoing, it is one object of the present invention to provide an ozone-based water purification system which incorporates in series an ozone generating apparatus and a mixer for mixing ozone-containing gas and a sanitizer prior to insertion of the mixed compounds into the water.

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It is another object of the invention to provide such an ozone-based water purification system wherein turbulence and mixing of the flow of water and bubbles is induced well downstream of the venturi. This keeps bubble size

small, and does not allow a buildup of ozone in water proximate the bubbles, allowing more ozone to dissipate into the water. In addition, this mixing and turbulence enhances killing of bacteria and viral organisms.

It is yet another object of the invention to provide a system wherein  
5 after the water is sanitized by exposure to at least ozone, any residual ozone remaining in the water is eliminated.

It is still another object of the invention to remove any atmospheric gasses from the flow of water after sterilization.

Other objects and benefits of the present invention will become known  
10 to those skilled in the art upon review of the detailed description which follows, and upon review of the appended drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagrammatic view of the instant invention.

15 Fig. 1a is a diagrammatic alternate view of the enclosure or housing shown in Fig. 1.

Fig. 2 is a sectional, partially exploded view taken along lines 2 - 2 of Figs 3 and 4.

Fig. 3 is an elevational view of an internal portion of an inlet venturi portion  
20 showing construction details thereof.

Fig. 4 is an elevational view of an internal portion of an outlet venturi portion showing construction details thereof.

Fig. 5 is an enlarged elevational view of a plug or stop for a check valve of the

instant invention.

Fig. 6 is an enlarged side view of the plug or stop as shown in Fig. 5.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

5 Referring now to the drawings, and in particular to Fig. 1, the instant inventive assembly for purifying water is referred to generally by reference arrow 10. The major components and compartments of assembly 10 may be, but not necessarily, be constructed integrally with or housed within a rigid casing 12, with access thereto provided by making one side removable. Such a  
10 casing 12 may be rectangular or square, as seen from a side, and relatively narrow in width so as to be conveniently mountable within a spa or hot tub enclosure. In this application, an enclosure about 18 inches high has proved to function well. For other applications, the configuration as shown and described conveniently compartmentalizes the assembly 10 for use in  
15 conjunction with pool plumbing systems, spa plumbing systems, drinking water systems and other similar applications. Conveniently, the compartments may be formed by a linear extrusion process where the extrusion is cut to length and capped at each end. In this instance, the internal structures for directing water flow are inserted from ends of the compartments, and may be  
20 mounted to the end caps.

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Referring further to Fig. 1, assembly 10 is shown having a number of compartments 14, 16, 18, 20, 22 and 24, each of these compartment communicating with adjacent compartments via openings at tops and bottoms



thereof so that the flow of water, as indicated by arrows, traverses the full length of each compartment. As shown in Fig. 1a, those compartments wherein water is flowing upward may be larger in cross section or diameter, and compartments wherein water flows downward may be smaller in cross section or diameter. Here, where the flow is upward, the flow is slower, allowing ozone in the bubbles a longer time to dissipate in the water. In those compartments where the flow is downward against gravity, the compartments are smaller with a corresponding increased flow of water that entrains the bubbles in a faster, more turbulent flow. Initially, compartment 14 serves as a contact chamber wherein bubbles containing ozone are first exposed to the water. Where compartment 14 is larger (Fig. 1a), the contact time is more prolonged. In addition, particular structures located in the compartments where the flow is downward or at entrances/exits thereof ensure that water flow is turbulent.

With respect to these structures, at an entrance 26 of compartment 16 is mounted a static mixer assembly 28, as shown and described in Applicant's pending patent application number 09/752,982, filed 12/31/2000, which is incorporated herein by reference in its entirety. Assembly 28 serves to generate turbulence in the flow of water for reasons earlier described. Within compartment 16, there are mounted a plurality of baffles 30 mounted at one edge 32 to the inner walls of the compartment, and have an opposite edge 34 angled or bent downward with respect to edge 30. With this construction, and as shown by arrows, the downward water flow through compartment 16 is

forced to take a circuitous path around baffles 30. Baffles 30 also generate turbulence in the water. Where an extrusion is used to form the compartments, baffles 30 may be mounted to a strip or rod. Alternately, a free-standing structure, such as a plurality of spheres having openings cut therein, may be placed in compartments wherein turbulence and extended contact distance is desired.

At the bottom of compartment 16 is a combination water exit/entrance 36 where the water exits compartment 16 and flows into compartment 18. Just as the flow of water enters compartment 18 it encounters a water-directing assembly 38 that forces the water to flow upward with a circular, spiraling motion. As stated, compartment 18 may be larger in cross section or diameter, allowing a prolonged contact distance as earlier described for compartment 14.

At an upper end of compartment 18, a combined water outlet/inlet 40 passes the water from compartment 18 to compartment 20. As the water flows into compartment 20, from outlet/inlet 40, it encounters a static mixer assembly 42 as described for static mixer assembly 28. Once in compartment 20, a smaller compartment, the flow of water is again forced to follow a circuitous path around baffles 44 constructed as described for baffles 30, and which are mounted to sides of the compartment (or to an end cap) and extend inward to direct the flow of water in a turbulent manner.

At a bottom of compartment 20, a water exit/inlet 46 is provided to pass the flow of water from compartment 20 to compartment 22. Here, as the

water flows into compartment 22, it encounters a second water-directing assembly 48 that directs the upward flow of water along a circular, spiral path. Alternately, the flow of water may be introduced into compartment 22 at an angle so as to induce a spiral motion to the water flowing through  
5 compartment 22.

Also positioned in compartment 22 is a watertight, sealed enclosure 50 within which an ultraviolet light-emitting lamp 52 is mounted or otherwise positioned. Lamp 52 is conventionally powered, as by a ballast connected to AC power and to the lamp. Watertight and airtight conductor connections  
10 through enclosure 50 would typically be employed. Enclosure 50 forms a portion of the ozone generator of the instant invention, as will be described hereinafter. Significantly, the walls of enclosure 50 are of a transparent, ultraviolet-transmitting material, such as, but not limited to, quartz, which passes the ultraviolet radiation to the water. In this compartment, water is  
15 forced to move in a spiral around enclosure 50 while being exposed to the ultraviolet light. This beneficially exposes any pathogens that may have survived to that point to lethal levels of ultraviolet radiation, and disassociates any residual ozone in the water into diatomic oxygen and free oxygen. Of course, the free oxygen so released is highly reactive, and reacts with  
20 practically any compound in the water almost instantaneously.

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At a top of chamber 22 is a water outlet/inlet 54 that passes the flow of water to the last compartment 24. Structure herein is similar to that shown and described in Applicant's pending application number 09/418,915, filed

10/15/99, and which is incorporated herein in its entirety by reference. This compartment 24 is provided with structure that removes entrapped air from the flow of water. Here, at a top of chamber 24 is a solenoid valve 54 that operates in conjunction with a water level sensor 56 and, in some instance, a valve 58 is positioned at an outlet 60 of assembly 10. A small drain chamber 55 may be provided in the vent line after valve 54 in order to trap and drain small amounts of water expelled through valve 54. Operation of valves 54, 58 and sensor 56 may generally be such that when sensor 56 detects a lowered water level indicative of a gas buildup within compartment 24, a signal is sent to valve 54 to open this valve, thus venting the gas. In instances where the water system is pressurized, water pressure forcefully expels the gas through valve 54. In some of these pressurized systems, where the water pressure is sufficiently high to expel gas through valve 54, valve 58 may be omitted. In instances where the water pressure is somewhat lower, a small constriction may be provided at an exit 60 in order to cause the gas to be expelled through open valve 54. In other of these pressurized systems where valve 58 is installed, valve 58 may be closed when valve 54 is opened. In this instance, pressure in the system increases to more forcefully expel gas through valve 54. In any instance, after the water level rises (due to the gasses being expelled) to a preset point where the water level almost reaches valve 54, sensor 56 closes valve 54. In order to prevent gas buildup in compartments with low flow rates, such as compartment 14, a small vent line may be installed from the top of the compartment to a top of compartment 24. This line would be sized so as to

readily vent gas, but not allow passage of a significant quantity of liquid to pass therethrough.

In other systems, such as gravity-operated flow systems, pressures in the assembly 10 are not as high. In this instance, valve 58 would be shut as valve 54 is opened by sensor 56. In these systems, when this occurs, the entire system would experience a drop in pressure, and a corresponding increase in pressure when valve 54 is closed and valve 58 is opened. Such pressure fluctuations are beneficial due to ozone diffusing more rapidly into the water when the pressure is higher. As a result, more ozone diffuses into the water sooner to develop initial higher concentrations of dissolved ozone.

Still referring to Fig. 1, another feature of Applicant's invention may include premixing ozone gas with another sanitizing compound prior to insertion of the mixed compounds into the flow of water. Here, a venturi injector 62 similar to a venturi injector as shown and described in Applicant's pending application number 09/393,437, and which is incorporated herein in its entirety by reference. This venturi 62 is conventionally provided with a water inlet 63 and a water outlet 65 through which a motive flow of water (as indicated by arrows) is pumped by a water pump (not shown). Venturi 62 is also provided with an annular cavity 65 (diagrammatically illustrated in Fig. 1) which in turn communicates with at least two sanitizer injection ports 64 and 66. As shown, port 64 may be coupled to a canister 68 having a removable top 70 within which a solid, slowly dissolving form of sanitizer is placed at appropriate intervals. An inlet line 72 provides a flow of water from the motive

flow to canister 68, where the sanitizer is dissolved into the water, and an outlet line 74 provides the water containing the dissolved sanitizer to inlet port 64. Inlet port 66 of the venturi is coupled to an outlet tube 76 of enclosure 50 through which air is circulated around ultraviolet tube 52. To accomplish this, 5 an inlet tube 78 is provided to enclosure 50. An air filter 80 may be coupled in line 78 to filter particulates from air circulated through enclosure 50. In some instances, an air pump 82 may be also placed in line 78 to pump air through enclosure 50. In any case, ozone-containing air from enclosure 50 is provided to port 66 of venturi 62, where the ozone-containing air is mixed with the 10 sanitizer-containing water from canister 68 in annular chamber 65 of venturi 62. Alternately, any sanitizer dispenser may be used, such as a liquid dispenser that dispenses a liquid containing a halogen or other sanitizer.

A multiport venturi 62 as contemplated by the present invention is more particularly described in Figs. 2 - 6. Here, it is seen that venturi 62 is 15 constructed in two portions or halves, an inlet portion 90 and an outlet portion 92. Nut/bolt pairs (not shown) extend through 8 pairs of aligned openings 93, 93a in each of portions 90, 92, and hold portions 90, 92 together while allowing disassembly thereof, as will be further explained. As shown, a flange 94 extends around a periphery of a body of inlet portion 90, flange 94 defining a 20 cavity 96 therearound. As shown in Figs. 2 and 3, small cavities 98, 98a generally receive sanitizing compounds from their respective inlets 64, 66, and channels 100, 100a carry the sanitizing compounds to an annular mixing cavity 102 where the sanitizing compounds are mixed. After being mixed, the

sanitizing compounds are drawn by venturi action across a flat venturi interface 104, as will be further explained, and into the motive flow of water flowing through opening 106.

The outlet portion 92 is provided on an external side with inlets 64  
5 and 66 for supplying sanitizers to the venturi. This may be the same sanitizer applied to each of inlets 64, 66 or dissimilar sanitizers may be applied to inlets 64, 66 as described above. In the latter instance, the dissimilar sanitizers are at least partially mixed prior to being introduced into the water flowing through the venturi. If course, inlets 64, 66 may be located on the inlet portion 90 with  
10 appropriate modification, as should be apparent to one skilled in the art. Inlets 64, 66 each communicate with respective cavities 108, 108a, these cavities provided with stepped regions 110, 110a where the cavities are reduced to a smaller diameter. Within these smaller diameter areas the cavity is tapered as shown toward inlet bores 64a, 66a and the respective openings through which  
15 sanitizing compound flows. Within these smaller-in-diameter and tapered portions of cavities 108, 108a disks 112, 112a of a thin, flexible material are placed, these disks serving as check valves to allow only a one way flow of sanitizer through inlets 64, 66. As these disks 112, 112a must move slightly within their cavities, the cavities are constructed slightly thicker and larger in  
20 diameter than the disks. For holding disks 112, 112a in place, plugs 114, 114a are provided, as particularly shown in Figs. 5 and 6. These plugs are sized to snugly fit as shown into the larger portions of cavities 108, 108a and loosely hold disks 112, 112a in place. These plugs each are provided with a

series of ridges 116 forming a plurality of grooves 118 in faces of the plug facing disks 112 (dashed lines in Fig. 5). As such, when sanitizer is flowing through the inlets 64, 66, the disks are moved away from the internal openings of the bores 64a and 66a and generally pressed against the grooves of plugs 114, 114a. As the disks are smaller than the radial extent of the grooves 118, sanitizer flows around the disks, into grooves 118 and through a central opening 120, 120a in the plugs. Openings 120, 120a in the plugs communicate via slots 100, 100a with annular mixing chamber 102, where the sanitizers are mixed and drawn into the venturi interface.

10            Additionally provided in outlet portion 92 is an annular cavity 122 surrounding opening 124 through which the motive flow of water flows from opening 106 of inlet portion 90. Together, annular cavities 102 and 122 form the cavity 65 diagrammatically shown in Fig. 1. A venturi interface 104a is located proximate venturi interface 104 of inlet portion 90, this dimension  
15            determined by thickness of a gasket 126 fitted between the inlet portion and outlet portion. Thus, the venturi may be adjusted for differing rates of flow by placing a gasket of appropriate thickness between the two portions. Here, where the flow rate is higher, a thicker gasket may be used, which in turn draws more sanitizing compounds into the venturi, and where the flow rate is  
20            lower, a thinner gasket may be used, which in turn draws less sanitizing compounds into the venturi. Of course, openings are cut in the gasket to allow flow of sanitizer therethrough and to allow motive flow of water through the gasket. Additionally, slots in the gasket may be cut along slots 100, 100a to



allow the sanitizers to more fully be mixed in both annular chambers 102 and 122.

While a number of features are shown in assembly 10, it is to be understood that a system with fewer features may be implemented, as should  
5 be apparent to one skilled in the art. For example, a viable system would include contact compartment 14, a single turbulence compartment 16 and an ozone generation/ reaction chamber 22. Further, in some systems, the gas removal compartment 24 may be omitted. In other systems, a conventional venturi may be used to inject ozone, with other sanitizers being conventionally  
10 dissolved in the water. Further, fewer turbulence-inducing assemblies may be employed. In venturi 62, multiple ports (more than 2) may be constructed therein, and the venturi itself may be scaled in size, in addition to adjusting the venturi gap depending on the flow

Having thus described my invention and the manner of its use, it  
15 should be apparent to one skilled in the art that incidental changes may be made thereto that fairly fall within the scope of the following appended claims, wherein I claim:

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